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BASIC BIRD MIGRATION CHARACTERISTICS IN LITHUANIA: TOWARDS LONG-TERM FORECAST IN BIRD STRIKE PROBLEM

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Summary

The paper contains an overview of the work carried out in south-east part of the Baltic region characterized by large-scale migratory movements of birds. The use of radar and complex methods of observation allowed to get a number of new characteristics of bird migration in the Baltic region, seasonal and circadian activities of birds, to determine migratory routes, flight directions and hights, to create model for forecasting large-scale migratory passages, to model migratory behaviour of birds. The results obtained can be used for long-term forecasting both in Lithuania and the entire region of the Baltic states.

Key Words: Bird Populations, Migration, Avoidance

INTRODUCTION

Solution of the bird strike problem is urgent as the part of air transport conveying passengers and luggage is constantly increasing and new types of aircrafts able to move at high speeds are being introduced in Baltic countries, including Lithuania. The more so as our investigations have predicted the number of collisions in the nearest future in Lithuania to increase five times. Thre greatest part of collisions occur during seasonal bird migrations.Thus investigation of various characteristics of bird migrations may contribute to the solution of bird strike problem. These characteristics may be used in long-term forecasting of bird migrations aimed at the enhancement of flight safety in aviation. The paper presents the newest generalized material on bird migration process not only over Lithuania but also over the entire region of the Baltic states.

METHODS

The work has been done in Vilnius and Palanga civil aviation airports located in continental and coastal parts of the country using radars and various instrumental and visual methods. This enabled to collect unique information on the scale of diurnal and nocturnal altitudinal bird migration as well as to define its characteristics over the whole territory of Lithuania, a part of Latvia, Byelorussia and Kaliningrad region of Russia, the Baltic sea and Kuršių Lagoon (Fig. 1). That permitted to obtain new data on the so far unknown invisible altitudinal bird migration which, according to our knowledge, makes up even 90% of all the birds migrating over the investigated territory. Observations of migrations was carried out by a 24-hour photoregistration of the screens of two radars with length of the wave 10 cm. Migrating flocks of birds were registered at the radius of 100 km (Fig. 2). The material was collected from 1974 to 1988 in spring and autumn.

FIGURE 1. Scheme of the range of radars used to study bird migrations in Lithuania

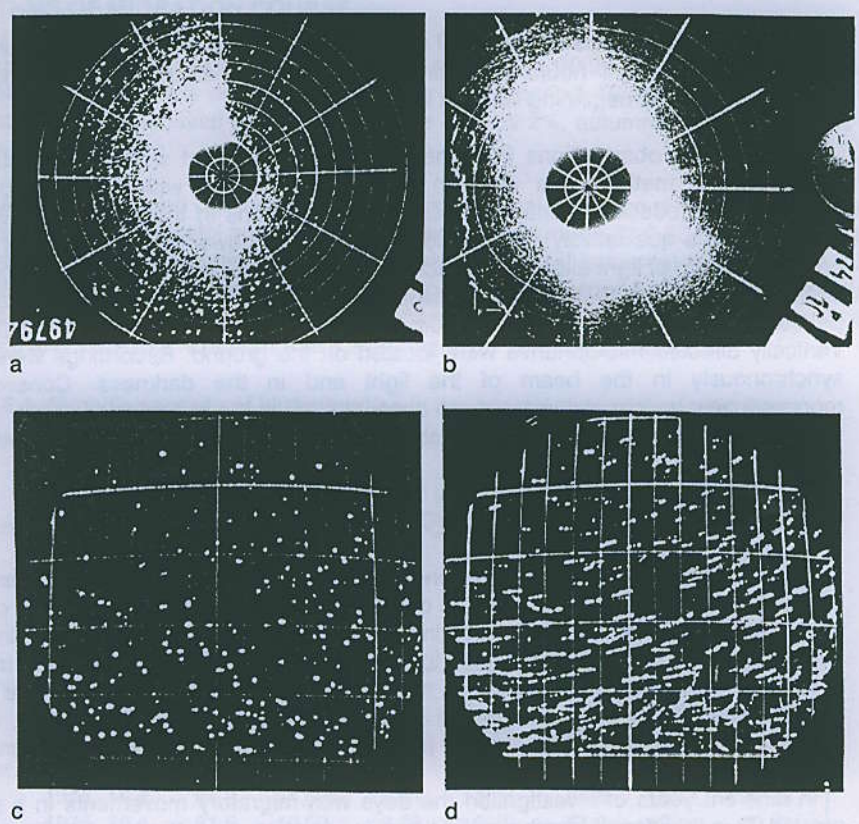

FIGURE 2. Mass waterfowl migration on p.p.i. (a, b). F - atmosferic front (b). Waterfowl migration pattern on the radar microscope scope screen (c, d). c - one revolution; d - 6 revolutions of the aerial.

To study the dynamics of nocturnal migration we used a widely accepted division of the night into consequent hours beginning with sunset. Analogically the timing of diurnal migration was done beginning with the local sunrise.

Visual diurnal observations from the stationary watchpoint were carried out. Nocturnal moonwatching method was used in spring and autumn with the help of telescope. Additionally introduced method of nocturnal observations in the dispersed electric light of hothouses in a qualitatively novel used method. Total power of all lamps was 1300 kW. A powerful stream of light allowed to watch birds at the altitude of 0.5 km, and a comparatively large lightened area (0.3-0.5 km in diameter) allowed to watch migrants for a rather long period of the time. The voices of nocturnal migrants were registered by two tape recorders. Vertically directed microphones were located on the ground. Recordings were carried out synchronously in the beam of the light and in the darkness. Consequently one moonwatching watchpoint was able to observe birds in the stream of the light, the other - in the darkness. This special experiment enabled to evaluate accuracy of used methods.

SEASONAL DYNAMICS OF MIGRATION

On the basis of the analysis of ten-day and diurnal intensity of diurnal and nocturnal migration of birds in different years of observation in the continental part and coastal zone, there was determined that in the continental part spring migration was more intensive than autumnal. It was more clearly defined for diurnal flight when mean intensity of migration in a ten-day period in spring was twice as much as in autumn. In the coastal zone of the Baltic Sea the intensity of diurnal migration in spring and autumn was the same, whereas the intensity of nocturnal flight in a ten-day period in autumn was twice as much than in spring.

In different years of investigation the days with migratory movements in a month didn't overlap. Due to different weather conditions, in separate years there were observed changes in seasonal dynamics of flight intensity. The difference in migration intensity in the same ten-day periods of different years may reach 10 and more times. In case of delayed spring, migration of birds starts later. In this case migration of maximum and high intensity proceeds in shorter terms than in the seasons when migration starts earlier.

Depending upon weather conditions the intensity of spring migration in the continental part reaches maximum meanings in the second and third ten-days of April. In separate years intensive migration may occur in the third ten-day of March - first ten-day of April. In autumn maximum migration was observed beginning with the third ten-day of August and proceeded throughout September. With every ten-day of October migration intensity was falling. In the coastal zone the intensity of spring migration was maximum in the second and third ten-days and considerably lower in the first ten-day of April. Maximum meanings of autumnal nocturnal migration in this zone are breached in the period from the second ten-day of September to the second ten-day of October, while maximum meanings of autumnal diurnal migration - in the third ten-day of September to second ten-day of October.

RHYTHMS OF MIGRATION COURSE

Diurnal spring migration over the coastal area made 30.8-36.5%, and diurnal autumnal migrations - 16.1-18.8% of the whole flight in a 24-h period. Respectively, nocturnal spring migration over the coastal area accounted for 63.5-69.2%, autumnal - for 81.2-83.9% of the whole 24-h migration.

The results obtained demonstrated that spring diurnal migration over the continental part, compared with the coastal area, was more intensive and made 34.0-35.4% of the whole 24-h migration. The same situation was observed during diurnal autumnal migration (21.4-27.1% of a 24-h migratory process). Accordingly, nocturnal migratory flights over the continental part are less intensive (in a 24-h period) than over the coastal area and make 64.6-66% (spring) and 72.9-78.6% (autumn) of a 24-h migratory process (Tables 1, 2).

TABLE 1. Circadian activity of bird migration in the coastal zone of the Baltic Sea

Season	Year	Diurnal flight, % of a 24 h period	Nocturnal flight, % of a 24 h period	Migration of 4 hours					
				% of a 24 h period			% of diurnal flight		
				morning	evening	morning and evening	morning	evening	morning and evening
Spring	1975	30.8	69.2	16.40	2.42	18.82	53.2	7.84	61.04
	1976	31.5	68.5	14.30	6.17	20.47	45.5	19.57	65.07
	1977	36.5	63.5	17.90	4.52	22.42	49.1	12.39	61.49
Autumn	1974	16.1	83.9	11.03	2.27	13.30	68.5	14.10	82.60
	1975	18.8	81.2	11.50	3.03	14.53	61.5	16.14	77.64
	1976	18.4	81.6	10.50	2.28	12.78	57.8	12.41	70.21
	1977	18.8	81.2	12.60	1.75	14.35	67.1	9.30	76.40

TABLE 2. Circadian activity of bird migration in the continental part of Lithuania

Season	Year	Diurnal flight, % of a 24 h period	Nocturnal flight, % of a 24 h period	Migration of 4 hours					
				% of a 24 h period			% of diurnal flight		
				morning	evening	morning and evening	morning	evening	morning and evening
Spring	1975	35.4	64.6	22.8	3.56	26.36	64.5	10.06	74.56
	1976	34.0	66.0	20.3	2.65	23.25	60.4	7.78	68.18
	1977	34.6	65.4	18.3	3.63	21.93	52.8	10.49	63.29
Autumn	1974	27.1	72.9	17.0	4.83	21.83	62.5	17.82	80.32
	1975	25.3	74.7	16.4	3.72	20.12	64.8	14.70	79.50
	1977	21.4	78.6	14.0	1.93	15.93	65.5	9.06	74.56

From the above we can see that diurnal autumnal migratory passage, compared with spring migration, is less intensive (nocturnal migration is less intensive in spring than in autumn). And diurnal migration over the continental part is more intensive than that over the coastal area (nocturnal migration is more intensive over the coastal zone compared with inland areas).

The analysis of diurnal migration demonstrated that the most intensive migratory passage occurred during the first four hours after sunrise. It was in this period that visual observations were carried out. Besides, migration intensity during the first four hours in the coastal zone in spring made 45.5-53.2% of migration intensity throughout the day, and in autumn - 57.8-68.5%.

In the continental part of the study region the intensity of spring migration during the first four morning hours made 52.8-64.5% of the diurnal flight, whereas the intensity of autumnal migration - 62.5-65.5%. To conclude with, the intensity of diurnal spring migration during first four hours after sunrise was lower compared with autumnal. This regularity is true both in the continental part and coastal zone of the Baltic Sea.

Comparison of morning intensity during four hours with the total 24 h intensity, due to different contribution of diurnal flight in a 24 h migration in spring and autumn, showed the opposite regularity. In the coastal zone morning intensity of four hours in spring made 14.3-17.9% of 24 h migration, and in autumn - 10.6-12.6%. In the continental zone in spring and autumn it made, re{pectivedy, 18.3-22.8% afd 14-17%. Thus, in spring apart of morning migration in a 24 h migratory flight is greater than in autumn.

DIRECTIONS OF SEASONAL MIGRATIONS

Migration directions in the continental part of the region

Diurnal spring migration. E-NE direction dominated with the following sectors: 71-80° (10.3% of all directions entering the diagram), 61-70° (9.8%), 51-60° (9.3%), 81-90° (8.3%), 41-50° (7.4%). These five sectors of directions made 45.26% of all directions. It should be noted that N-NW direction (sectors 331-340° and 341-350°) was the second dominant direction.

Nocturnal spring migration. According to radar data, the summary diagram of migration directions during three years shows that E-NE and NE directions prevailed. Dominating sectors of directions were: 71-80° (12.5% of all directions included in the diagram), 51-60° (11.3%), 61-70° (10.2%), 81-90° (9.9%), 41-50° (9.0%), 91-100° (7.86%). The most defined six sectors make 60.8%.

Diurnal autumnal migration. From the summary diagram of radar observations we see that the main directions of migration were close to S and SW. The first direction is more defined, especially in the sectors with the following azimuths: 171°-180° (11.1%), 161-170° (8.5%),

151-190° (6.5%), 151-160° (5.8%), 191-200° (5.1%). These five sectors in the azimuth of 151° to 200° made 36.95% of all directions of the migration described.

The following sectors were most obvious in SW direction of migration: 231-240° (9.0%), 221-230° (8.6%), 241-250° (7.4%), 211-220° (7.0%), 201-210° (6.2%).These five sectors in the azimuth of 201° to 250° accounted for 38-8% of all directions of diurnal autumnal migration.

Nocturnal autumnal migration. According to radar data, the summary dendrogram shows that SW direction with the following sectors dominated: 221-230° (11.45%), 231-240° (11.3%), 211-220° (9.5%), 241-250° (9.1%), 251-260° (7.9%). They accounted for 49.2% of all directions. Besides, S-SW and S directions were significant to some extent.

Migration directions in the coastal zone of the Baltic Sea

Diurnal spring migration. According to radar data in the course of three seasons E-NE direction dominated with the prevalence of these sectors: 51-60° (14.6%), 61-70° (13.3%), 41-50° (11.95%), 71-80° (9.1%), 31-40° (8.2%). These sectors accounted for 57.2% of all directions of the described migratory pattern. NW flight was weakly defined.

Nocturnal spring migration. According to radar data in the course of three seasons the most expressed direction was NE and less - N-NE. In the main direction the following sectors dominated: 51-60° (13.7%), 41-50° (12%), 61-70° (10.2%), 31-40° (9.4%), 21-30° (8.4%), . These sectors made 53.7% of all directions included in the diagram.

Diurnal autumnal migration. In the course of 4 years of investigation the main direction was SW and less marked - SE. Migration dominated in the following sectors: 231-240° (8.7%), 221-230° (8.6%), 211-220° (8.2%), 241-250° (6.4%), 201-210° (5.7%) accounting for 37.5% of all directions entering the diagram. The sectors of SE direction (111-160°) make merely 15.3% of all directions.

Nocturnal autumnal migration. SW direction dominated. The second important direction was SE, and the weakest flight occurred in NE direction.

The sectors of the main direction are: 231-240° (8.3%), 221-230° (7.5%), 211-220° (7.1%), 241-250° (6.8%), 251-260° (6%). These five sectors make 35.6% of all directions included in the diagram. SE direction in sectors with azimuth of 111° to 160° makes 14.2% of all directions.

According to visual observations, in all migratory processes, we find a great diversity in directions. There was distinguished reverse migration in the day-time especially in the beginning of the season. Direction of the flight is influenced by the coastal lone of the sea directing bird in the northern or south azimuth.

MIGRATION ALTITUDES

Altitudes of visual diurnal migration

Diurnal spring migration. The majority of birds (79.8% of all registered) move over the Kuršių Nerija spit at the altitude of 0-50 m. The altitude of 51-100 m was registered in 13.8% of migrants, 101-150 m - in 1.82% and 151-200 m - in 1.96%. Migration altitude greatly depends upon wind conditions. Under strong winds of all azimuths the birds fly at 10-50 m, under moderate E, SE and S winds - at 50-200 m, and under weak winds - at 1000-2000 m and higher (up to 3000 m).

Visually observed geese migration occurred basically at the altitude not exceeding 200 m (78.8% of all birds).

Diurnal autumnal flight. The most intensive flight occurs at the altitude of 1-50 m. (87.2% of all birds registered). 7.6% of birds move at 51-100 m. Migration altitude is the greatest under weak following wind, and the lowest - under strong wind. According to the data of telescopic observations against the background of the Moon, the main bulk of migrants moving at higher layers (1000-2000 m) use N (15-40%) and weak side - E (40-50%) wind. The flight at high altitudes is characteristic not only of middle- and large-size birds (divers, ducks, geese, birds of prey, birds of Corvidae family), but also of small passerines (Skylark, thrushes, Starling, Chaffinch) accounting for ca 90% of all birds registered at high altitudes . Other species: Great Crested Grebe, Red-breasted Merganser, different species of waders - prefer flying at low altitudes.

Most geese (65%) over the territory of Lithuania were observed within 200 m, though migratory movements of these birds were rather intensive also at the altitude of 450-550 m (18.6% of all geese registered). There were observed birds keeping very low altitudes (1-3 m) as well as separate flocks flying at 1000 m and even 3000 m (detected with the help of a telescope).

Flight altitudes of nocturnal migrants

Nocturnal autumnal flight. According to the data of nocturnal telescopic observations against the background of the Moon, carried out in 1976-1977 in the Kartena watchpoint (25 km from the coast of the Baltic Sea), the highest density was registered within 400 m (46% of all migrants). A considerably intensive migration was detected at the altitude of 400-800 m (26.9%). At greater altitudes migration density was decreasing (5.3% at 800-1000 m; 6.1% at 1400-1600 m etc.).

The radar assessment of the altitude of the Common Scoter migration to moult by the end of July to the beginning of August revealed that over the continent the birds move at 1000-2500 m, and over the sea - at 100-600 m. Increase in altitudes was observed with twilight after sunset.

In autumn 1986 we carried out an experiment on the study of migrations with the help of a complex of methods (including a new method of nocturnal observations in dispersed electric light of hothouses). With the help of telescopes there was determined that in autumn 1986 in the area of the control point (in the darkness) the main bulk of birds moved at the altitude within 200 m (59.1%). 69.5% of birds were detected within 400 m, 86.2% - within 1 km. Close to the aero-illuminated by hothouses 77.5% of all birds detected by the lunar method moved at the altitude within 200 m and 87.5% - within 400 m. In separate night of the season the height of the flight of migrants varied occasionally reaching the altitude of 2 km. It should be indicated, however, that generally 75% of all registered bird were detected within 800 m. The birds, which in the darkness moved in the altitude up to 1 km, coming closer to hothouses lowered the altitude of the flight to 400 m.

PECULIARITIES OF MIGRATION COURSE

In different parts of the study region migration intensity is closely related with wind directions dominating in the season. The number of days or nights with maximum and high intensity of migration in the continental part of the study region increases with strong W winds frequently registered in the season. Whereas the number of days with low intensity in both zones of investigation increases to the account zero migration in the coastal area, and in the continental part of the study region with high intensity of migration the birds change their common directions compensating for wind drift.

While processing radar data there was detected a diversity in the intensity of nocturnal and diurnal migrations in spring and autumn as well as over the continental part of the country and coastal area of the Baltic Sea.